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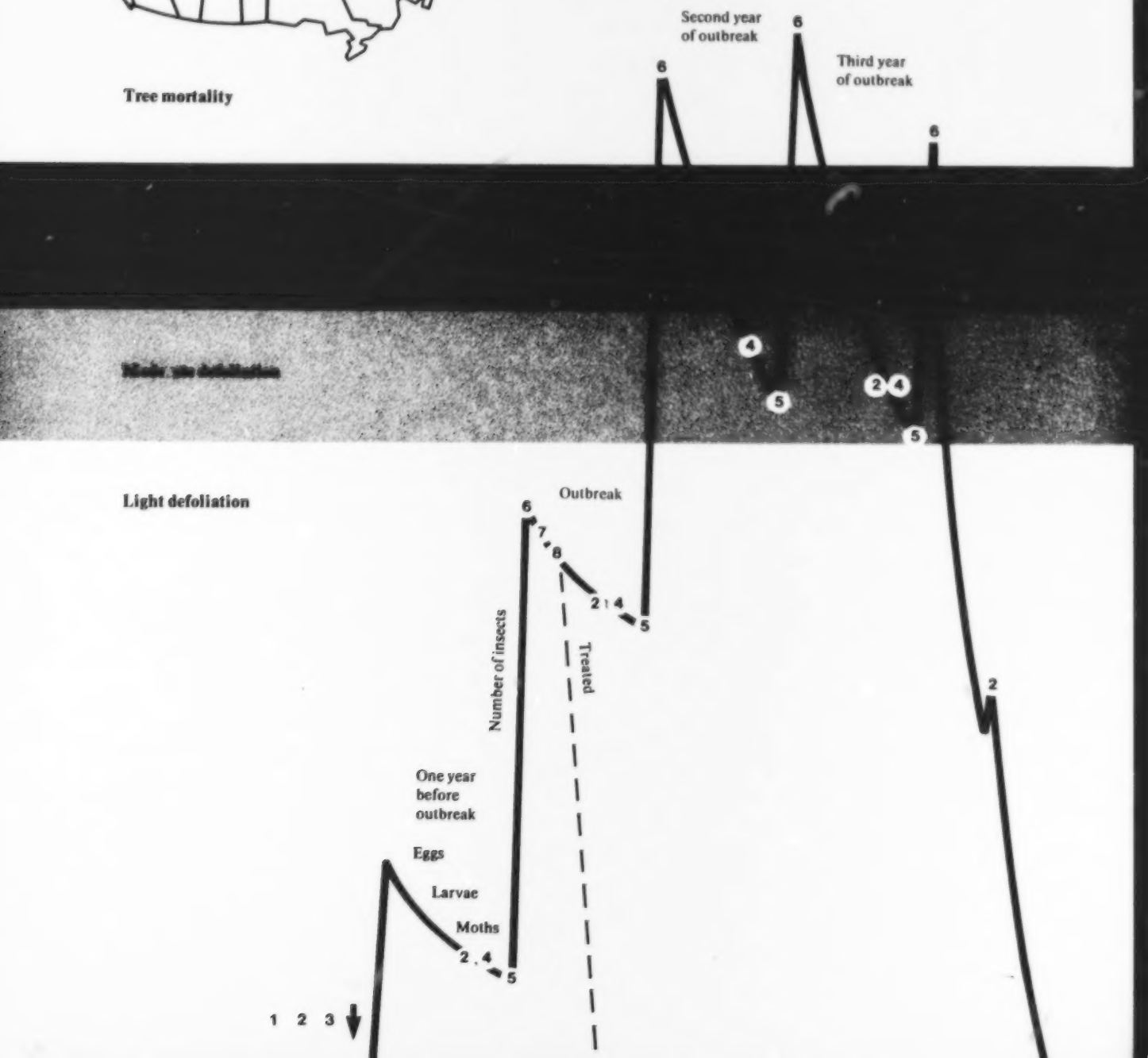
Pest management of Douglas-fir tussock moth: procedures for insect monitoring, problem evaluation and control actions

Roy F. Shepherd and Imre S. Otvos

Information Report BC-X-270
Pacific Forestry Centre

Tree mortality



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SCHEDULE OF PROCEDURES

The essential steps and procedures of the pest management system for the Douglas-fir tussock moth in British Columbia are listed with the approximate time of initiation relative to the first year of defoliation.

1.	Planning stage-before problems arise	Identify stands susceptible to Douglas-fir tussock moth outbreaks by comparing overlays of maps of historical outbreaks, forest types, plant communities and climatic zones (map for British Columbia is on back cover).
2.	July to September annually	Within susceptible stands, establish and maintain monitoring sites to determine year to year trends in number of moths caught in pheromone traps (in British Columbia these are maintained by the Canadian Forestry Service).
3.	October annually	Check pheromone traps and if catches at the permanent monitoring sites have increased for at least 2 years and moth density has reached 8-10 moths/trap, an outbreak is probably only two years away; initiate (4).
4.	July of each year until the outbreak subsides	Deploy a network of auxiliary pheromone traps to help locate infested stands.
5.	October of each year until the outbreak subsides	If moth counts in pheromone traps at the permanent monitoring sites have increased for 2 to 3 years and average moth density has reached 25 moths per trap, an outbreak may be expected the following year; initiate (6).
6.	October of each year until the outbreak subsides	Search for egg masses in stands close to permanent or auxiliary traps which caught an average of 25 or more moths per trap. When a pocket of egg masses is found, determine the density through a lower-branch sequential egg-mass survey and predict the level of defoliation for the next year; initiate (7).
7.	November of each year until the outbreak subsides	If egg masses are present, consider all available options for managing the insect problem. If insecticide or virus treatment or harvesting is chosen, conduct surveys to map infestation boundaries, determine areas, timber volumes etc. as necessary and plan the operation.
8.	May or June in year when defoliation is expected	If the harvest option is chosen, completely cut the infested stands and burn the residual slash by May prior to larval hatch. If insecticide or virus control is chosen, carry out application immediately after larval hatch and dispersal.

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Abstract

Procedures are described for detecting impending outbreaks of Douglas-fir tussock moth, *Orgyia pseudotsugata* (Lepidoptera: Lymantriidae). Areas susceptible to outbreaks are determined by overlaying maps of past outbreaks onto maps of forest types, plant communities and climatic zones. The time and location of the next outbreak is indicated by monitoring annual trends of moth density with pheromone traps. Pockets of high population are confirmed by ground reconnaissance. Sequential egg-mass and larval sampling systems are used to determine insect density and predict defoliation for the next year. Advantages and disadvantages of the various control measures are discussed and examples are given for different situations.

RÉSUMÉ

Nous décrivons des méthodes employées pour la détection des infestations imminentes de la chenille à houppes du douglas (*Orgyia pseudotsugata*) [Lepidoptera: Lymantriidae]. Les endroits prédisposés aux infestations sont déterminés par superposition de cartes des infestations antérieures sur des cartes des types forestiers, des communautés végétales et des zones climatiques. Le moment et l'emplacement de la prochaine infestation sont déterminés par surveillance annuelle de l'évolution de la densité des papillons à l'aide de pièges à phéromone. Les foyers de population élevée sont confirmés par reconnaissance sur le terrain. Des échantillonnages séquentiels des masses d'ouefs et des larves sont effectués pour déterminer la densité de l'insecte et prévoir la défoliation pour l'année suivante. Nous examinons les avantages et inconvénients des diverses mesures de répression et présentons des exemples pour diverses situations.

Acknowledgement

The B.C. Ministry of Forests participated in many of the research projects which were necessary to develop the components for this pest management system. Their support is gratefully acknowledged. Details of the component studies have been described in individual publications which are listed in "Sources of Additional Information."

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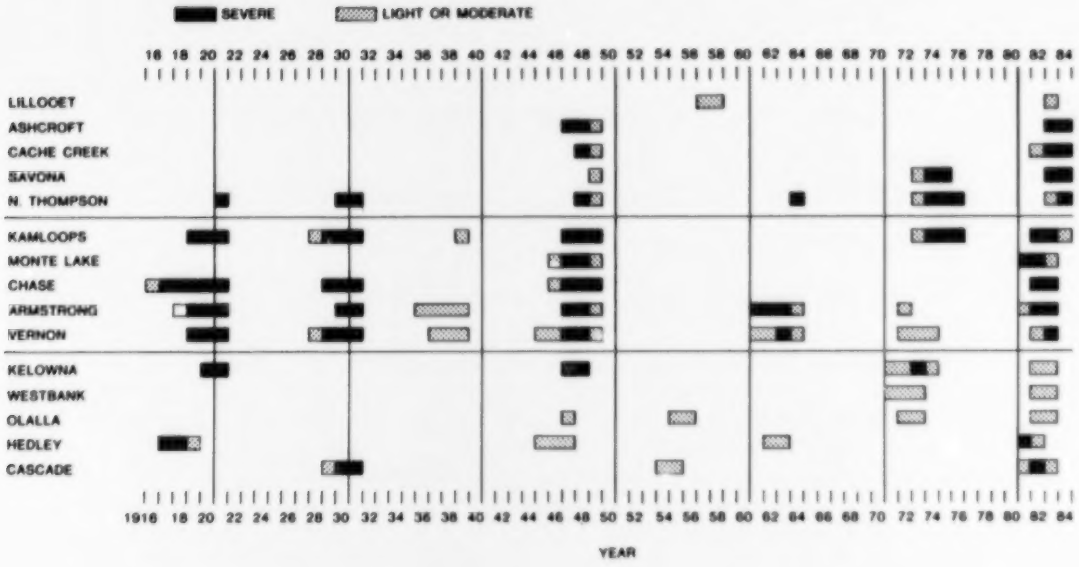

Fig. 1. Histogram of Douglas-fir tussock moth outbreak periods from 1916 to 1984 by geographical locations in British Columbia.

INTRODUCTION

Outbreaks of the Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough), occur at intervals of about 8 to 14 years somewhere within the Okanagan and Thompson River valleys of British Columbia (Fig. 1). Defoliation of Douglas-fir, *Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco, its principal host, can appear with little warning and result in severe damage in the first year. Usually the outbreaks last 1 to 4 years in a stand before populations disappear (Wickman *et al.* 1973); considerable growth loss, deformity and tree mortality (Fig. 2) can occur in this short period. Defoliation occurs in distinct patches in the first year. These patches may spread and coalesce in the second and third years of the outbreak. As the adult female is flightless, dispersal of the tussock moth is restricted to the larvae which drift on the wind on silk threads or crawl to surrounding trees.

Eggs hatch just after bud flush and the young larvae feed on new foliage. At high larval densities the new foliage may be consumed in 2 or 3 weeks and the larvae are forced to feed on old foliage (Brooks *et al.* 1978). Feeding continues for another 4 to 6 weeks, concentrating at the tops of the trees. Larvae pupate in cocoons (Fig. 3), usually on the underside of foliage and branches but, at high population levels, they may also pupate on tree trunks. Flightless female moths emerge, mate with winged males and lay eggs on their cocoons in August and September. They overwinter as eggs (Fig. 4), providing a relatively stable stage for surveys during the next 6 months. This report outlines procedures forest managers can use to follow and manage Douglas-fir tussock moth populations. Susceptible areas are identified by overlaying maps of past outbreaks onto maps of forest types, climatic zones and plant communities. Endemic population densities are monitored within susceptible stands with pheromone traps. Ground reconnaissance near indicator traps is used to locate infested stands and predictions of defoliation are made from egg-mass and larval sample surveys.

Various control options are reviewed and implications of each course of action are discussed. Careful consideration should be given to all the options during the pre-outbreak period. Once the outbreak is underway the number of viable alternatives decreases significantly. Where warranted,

Fig. 2. Stand of Douglas-fir killed by Douglas-fir tussock moth.

Fig. 3. Cocoon of male Douglas-fir tussock moth.

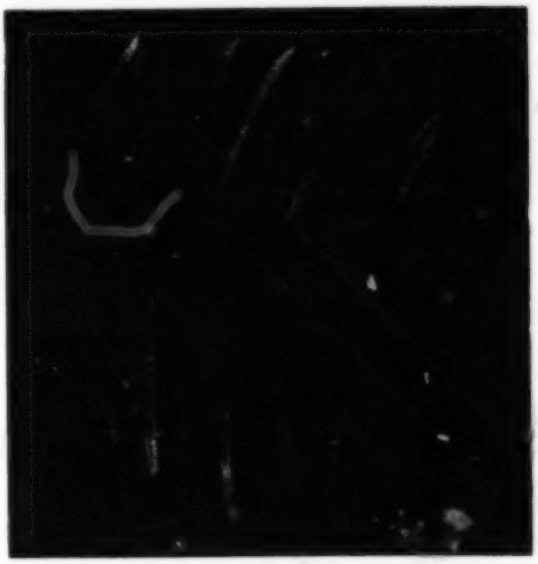

Fig. 4. Egg mass of Douglas-fir tussock moth.

treatments should be applied before there is significant defoliation in order to prevent or reduce damage, rather than after defoliation has appeared with its associated growth loss, dieback or mortality.

PROCEDURES

Identifying susceptible stands (1)*

In the planning stage between outbreaks, stands susceptible to Douglas-fir tussock moth can be identified by studying historical outbreak maps and superimposing these on maps of forest types, plant communities and climatic zones. The overlay will identify the most susceptible stands and permanent monitoring pheromone sites should be established within these zones. The map on the back cover indicates the susceptible zones in British Columbia.

Monitoring low tussock moth populations with pheromone traps (2) (3) (5)

Permanent pheromone monitoring sites should be established about 30 km apart within Douglas-fir stands susceptible to tussock moth outbreaks. In British Columbia, the Forest Insect and Disease Survey of the Canadian Forestry Service maintains 19 of these permanent monitoring sites (Map, back cover). They annually determine pheromone-trap catch densities as a means of monitoring population trends of the moths. This information is communicated to the B.C. Ministry of Forests, who, in turn, pass it on to any affected land owners or timber tenure holders.

Six triangular-shaped traps with sticky inside surfaces, each with a lure containing 0.01% pheromone, are hung in Douglas-fir trees approximately 40 m apart at each of the permanent monitoring sites in late July (Shepherd *et al.* 1985b). These traps are recovered in October after moth flight has ceased. The moths caught in each trap

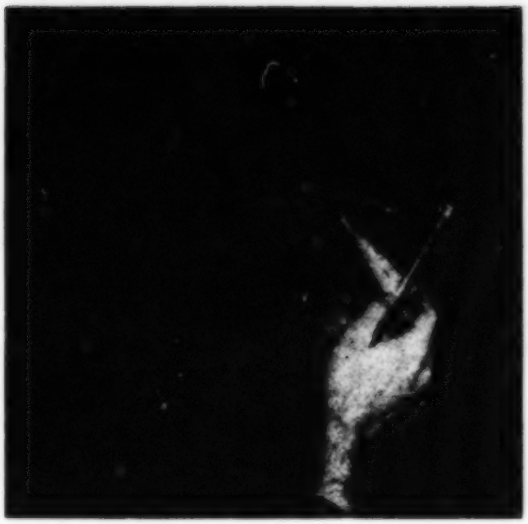

Fig. 5. Pheromone trap.

are counted (Fig. 5). Only moths of the correct tussock moth species should be included. Since annual trends are the important criteria, it is important that traps, lures and sites remain constant from year to year. When a consistent upward trend is found in a given stand for two years, and the average catch reaches 8 to 10 moths per trap, the next outbreak is probably two summers away. An auxiliary pheromone trap network should be deployed the next year to aid in the location of the incipient infestations. When a consistent upward trend is found at the permanent moth monitoring sites for 2 or 3 years and the average number of moths caught per trap reaches 25 or more, an infestation probably exists and egg-mass surveys should be initiated the same autumn in the vicinity of the auxiliary traps with the highest catches.

Locating infested stands (4)

The permanent trap system indicates when an outbreak is expected, but infested stands are located by ground reconnaissance of susceptible stands. In the autumn, stands are surveyed for egg masses near permanent pheromone monitoring sites that recorded an upward trend. The area of search can be reduced by deploying auxiliary pheromone traps every 1 to 3 km along all access roads around the permanent monitoring sites the year before defoliation is anticipated (Shepherd *et al.* 1985b).

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* Numbers in parentheses refer to steps in the "Schedule of Procedures."

Measuring insect densities and predicting damage (6)

A survey method has been designed to determine egg-mass densities as a basis for predicting defoliation for the following year (Shepherd *et al.* 1984a). It is used for assessing tussock moth populations before significant defoliation occurs. A ground search of susceptible stands is made in the vicinity of the pheromone traps indicating impending outbreaks. When egg masses are found, the center and extent of the infestation is delineated by visually scanning lower branches of surrounding trees. A sequential egg-mass survey is taken at the center of the infestation where egg-densities are hightest to indicate the most severe damage to be expected in the stand (Shepherd *et al.* 1985a). Other parts of the stand will probably suffer less damage.

At the infestation center, 20 trees are selected randomly and three lower branches of each tree are scanned for egg masses (Fig. 4). Cocoons or hatched egg masses from the previous year must not be included in the count. The cumulative number of egg masses is determined for the 20 trees and checked against a table of required sample size. If the cumulative number is above or below specified upper or lower thresholds, sampling can cease. If the number is between the thresholds, additional trees are sampled until either the upper or the lower threshold is crossed.

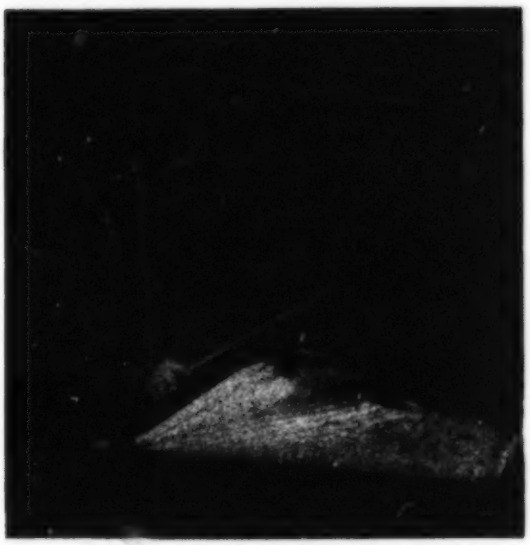

Fig. 6. Sampling for small Douglas-fir tussock moth larvae.

Damage predictions are made from the average number of egg masses per tree. Light defoliation occurs when the average is under 0.7 egg masses per tree and severe defoliation is expected when the average is above 2.0 egg masses per tree. Fewer than half of the trees in a lightly defoliated stand will lose their current foliage in the upper crown and only a small amount in the middle or lower crowns; a minor reduction in diameter growth can be expected. In a severely defoliated stand, the majority of trees will lose all or most of their current foliage and at least one-half of their older foliage; at least one-fifth of the trees will be completely defoliated. Significant growth loss and some dieback and tree mortality will occur in such stands. At intermediate defoliation levels, growth will be reduced but little dieback or tree mortality can be expected.

If a further check on population density is required or a new infestation is located in the spring, a similar lower-branch sequential survey method is available for newly hatched larvae (Fig. 6) (Shepherd 1985; Mason 1978). A 60 × 90 cm canvas tray is held under the terminal of each branch and the young larvae are beaten from the branch and counted. Three lower branches are sampled per tree and the number of trees examined is determined from a table of required sample size.

Criteria for action (7)

After an infestation has been identified, a decision must be made on a course of action. The main criteria that should be considered in reaching that decision are listed below. Other factors may be important under certain local conditions.

Management objectives of the stand. The course of action selected should be consistent with the long-term stand management objectives. These objectives may include timber production, auxiliary forage production, enhancement of amenity values, shade and visual benefits around suburban homes, wildlife habitat and watershed protection. Different treatments may be selected to meet different objectives, therefore, each stand has to be considered individually.

The cost of various treatments must be weighed against the present and future value of the stand.

Fig. 7. Douglas-fir tussock moth larvae killed by virus.

A mature, commercial forest could be harvested rather than treated but a young forest with considerable growth potential, may have to be protected. Protecting residential or shade trees around a ranch home, for instance, can be important to future market values of the property (Ross and Taylor 1983). In contrast, letting an outbreak run its natural course in grazing areas may be considered beneficial by the rancher as defoliation opens up the stand and increases forage production.

Expected defoliation next year. The tussock moth population density, the present point in the outbreak cycle and the current incidence of disease in the population will all affect next year's damage. The egg-mass density can be measured and used to predict the level of defoliation for next year (Shepherd *et al.* 1984a), but this level will be reduced if the outbreak is in its third or fourth year. If dead larvae are commonly found hanging from the branches (Fig. 7) or if egg masses are small, distorted and incompletely covered with hairs, the population is infected with virus and no additional defoliation will occur.

Condition of trees. An important consideration in deciding between a insecticide or virus treatment is the condition of the infested trees. There is a 5 to 8 week incubation period after virus application before the larvae cease feeding and, unless the trees can withstand additional defoliation, an insecticide treatment may be necessary. Similarly, if the trees have a diameter greater than 40 cm at breath height and if a Douglas-fir bark beetle (*Dendroctonus pseudotsugae* Hopkins) population is active nearby, defoliation may not be tolerable as the weakened trees may become susceptible to attack and succumb to this beetle (L. McMullen, pers. comm.). In this case, insecticide treatment or harvesting may be the only viable alternatives.

Silvicultural considerations. Many susceptible stands are located on hot, dry sites where shelterwood harvesting is necessary to maintain protective shade for seedlings. Loss of the standing trees due to defoliation or subsequent bark beetle attack may endanger survival of the Douglas-fir regeneration. However, shelterwood cutting within an infestation would not produce any protection from the insect for the remaining trees and, if tops and branches of logged trees containing egg masses are left in the forest, dispersing newly hatched larvae may concentrate on the remaining trees. Also, defoliated trees rarely produce seeds for a number of years after an outbreak has collapsed and until the crowns have regrown. Thus, harvesting of an infested stand, from a silviculture point of view, may not be feasible unless the regeneration is already established and can be protected by a virus or insecticide application.

Human health problems. Irritating hairs on larvae and egg masses, which are present in infested forests, may cause tussockosis or severe allergic reactions in some people (Perlman *et al.* 1976) (Fig. 8). Such people may find it impossi-

Fig. 8. Photomicrograph of irritating hairs from Douglas-fir tussock moth caterpillars and egg masses that may cause an allergic reaction (× 160).

ble to continue working or living in an infested forest. Felling and extracting infested trees is a particularly bad situation for these people because the air and dust becomes contaminated with the hairs. In addition, many people find caterpillars objectionable and infested campgrounds and parks will be avoided, giving rise to financial losses.

Treatments available

The selection of the best treatment for an area depends upon the feasibility of application and costs of each treatment, as well as the criteria discussed above.

Virus treatment. The main advantage of virus treatment is the specificity of the effective material which reduces the environmental constraints. In addition, ground application is feasible (Fig. 9) as the virus will spread from the point of application; partial treatment of stands and spraying the lower crown of large trees is often sufficient. Aerial treatment will be necessary if the stand is large or inaccessible. This treatment is ideal for early treatment of incipient outbreaks a year before significant defoliation is expected (Shepherd *et al.* 1984b). However, because of the long incubation of the virus, foliage protection may only be minimal in the year of application. The supply of virus is limited and, at present in British Columbia, is only available through the B.C. Ministry of Forests. The cost is relatively high.

Fig. 9. Nuclear-polyhedrosis virus application from the ground.

Insecticide treatment. The main advantage of insecticide treatment is the speed with which further damage to the trees is prevented. However, watershed or other environmental constraints have to be considered and may exclude its use in some cases. If only a few trees are treated, they may be subject to re-invasion by crawling or wind-drifting larvae from nearby infested trees. Generally, to be effective, the entire infested area or at least a large contiguous block of infested forest needs to be treated aerially. Good control is essential because if large trees are partially defoliated due to poor application or ineffective material, then a Douglas-fir bark beetle outbreak could follow. This happened in 1976 following an application of *Bacillus thuringiensis* Berliner (Shepherd 1980). In British Columbia, information on insecticides recommended for the Douglas-fir tussock moth and restrictions on their use can be obtained from the Pesticide Control Branch, B.C. Ministry of Environment.

Harvest the stand. Cutting the trees before there is damage may be a viable management strategy provided the stand is harvestable, market conditions are good, and the area can be replanted as soon as the outbreak is over. Additional stands may have to be included to make the cutting operation economically viable. Replanting with a non-susceptible species such as ponderosa pine which is better adapted to dry site conditions (Illingworth and Clark 1966), or changing to some other land use such as grazing, should also be considered.

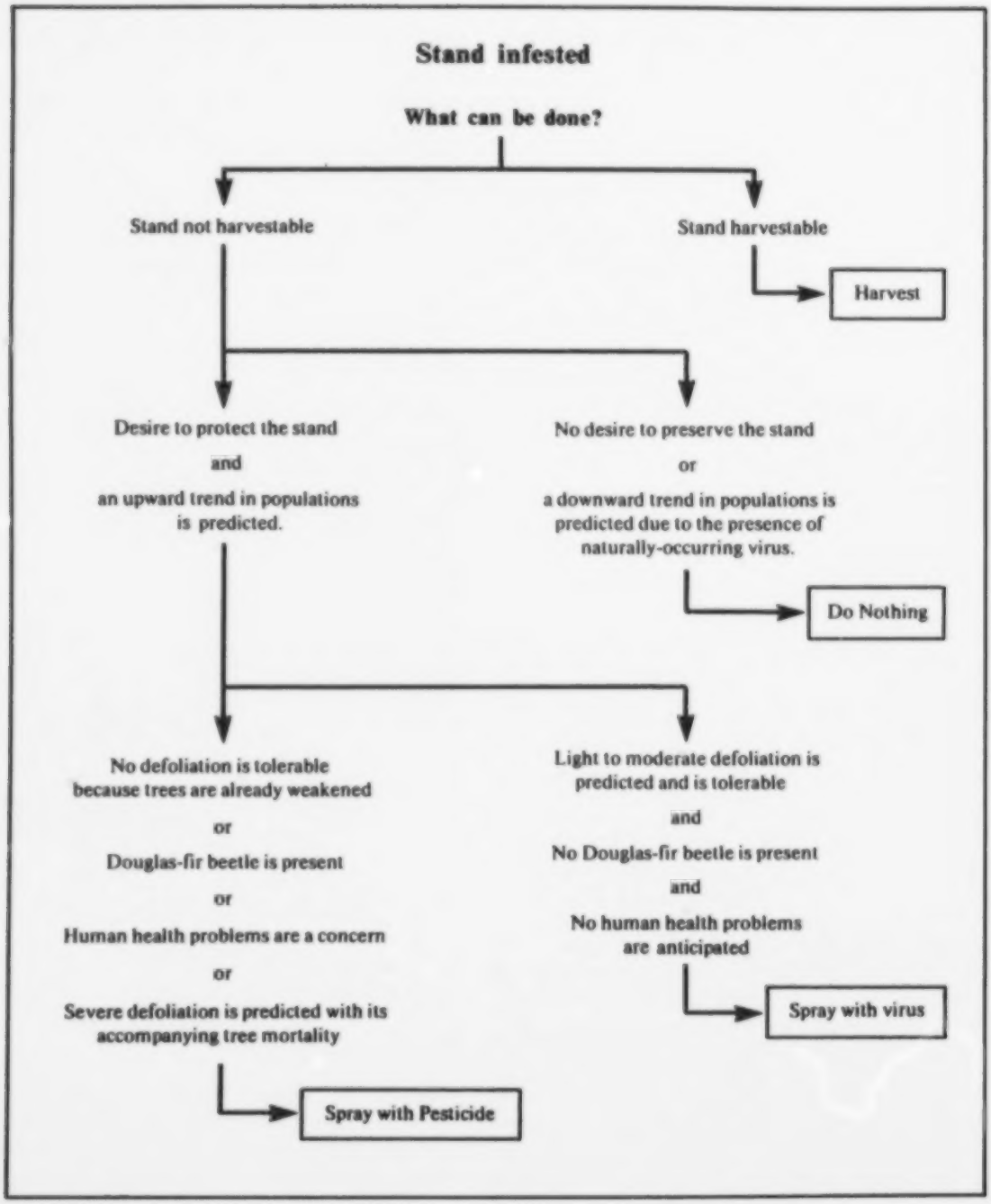
Stand infested
What can be done?
Stand not harvestable
Stand harvestable
Harvest
Desire to protect the stand
and
an upward trend in populations is predicted.
No desire to preserve the stand
or
a downward trend in populations is predicted due to the presence of naturally-occurring virus.
Do Nothing
No defoliation is tolerable because trees are already weakened
or
Douglas-fir beetle is present
or
Human health problems are a concern
or
Severe defoliation is predicted with its accompanying tree mortality
Spray with Pesticide
Light to moderate defoliation is predicted and is tolerable
and
No Douglas-fir beetle is present
and
No human health problems are anticipated
Spray with virus

Fig. 10. An example of a step-wise selection process for a course of action when a tussock moth outbreak is present or threatening; local circumstances could change the selection considerably.

Do nothing. If the outbreak is allowed to run its course without intervention then costly clean-up, site rehabilitation and planting may be required. The salvage value obtained for logs from dead trees may be considerably lower than the green-tree rate and seedling survival may be poor if the shading effect of the overstory trees is lost. However, this option may be chosen on some inaccessible or nonproductive sites.

Virus is usually the best choice at the early stages of an outbreak before there is significant defoliation. After one year of defoliation, insecticide treatment is often a better choice as it will prevent further damage to the weakened trees, immediately reduce possible allergic reactions, and lessen the chance of a Douglas-fir bark beetle outbreak. Harvesting a mature stand is preferred before there is tree mortality as the logs will retain their value. However, if a shelterwood cut is applied, the residual trees and regeneration must still be protected.

When an infestation does occur, the forest owner should obtain all the information available and make a decision on a course of action (Fig. 10). Even if the decision is to do nothing, it should be taken with full realization of the possible consequences. It is also important to become aware of the problem before any defoliation occurs. Once defoliation begins, some options, such as virus treatment, may be lost and the owner may be forced to take less desirable actions. Also, as an outbreak proceeds, other complications can develop, such as a Douglas-fir bark beetle outbreak, which can compound or enlarge the problem. The key to a successful pest management program for Douglas-fir tussock moth is to plan ahead and be aware of all possibilities. The objective should be to prevent the problem rather than treat it after the fact. If possible, control actions should be undertaken before the damage is done.

Planning the action (8)

Considerable information and time are necessary to plan and conduct any control action. The timing of the various control actions is planned in relation to the timing of egg hatch. Egg hatch occurs in late May and should be closely monitored (Fig. 11). If harvesting is the preferred treatment, then all logging, log processing and slash burning should be completed before egg hatch to prevent the spread of the insect. If virus or insecticide treatment is preferred, then these should be applied as soon as 80% of the egg masses have hatched and the larvae have moved to the foliage. Planning a spray program is highly complex and requires considerable lead time. Therefore, the field aspects of determining insect densities and mapping of proposed spray areas should be completed in the fall to provide the basis for all subsequent planning during the winter.

Fig. 11. Young Douglas-fir tussock moth larvae hatching from an egg mass.

Continued surveillance

Outbreaks generally last 1 to 4 years in any one area and during this time newly defoliated stands appear each year. Therefore, it is important to continue auxiliary pheromone monitoring and ground surveillance every year until the outbreak has subsided.

The schedule of procedures outlined above is common in British Columbia, but elsewhere outbreaks do not always appear as quickly as noted here. For instance, in the grand fir, *Abies grandis* (Dougl.) Lindl., forests of Washington and Oregon, it is common to have an additional year before defoliation appears after the critical pheromone-trap densities are reached (Gregg and Twardus 1981).

Sources of additional information

For further information contact the local office of the British Columbia Ministry of Forests or the Canadian Forestry Service. Publications dealing with specific components of the management system referred to in this report are available from the Canadian Forestry Service. Pacific Forestry Centre, 506 West Burnside Road, Victoria, B.C., V8Z 1M5.

Annual Reports — Canadian Forestry Service, Forest Insect and Disease Survey, Kamloops region.

Illingworth, K. and M.B. Clark. 1966. Planting trials with ponderosa pine in British Columbia. B.C. For. Serv., Res. Note 41.

Perlman, F.D. Press, J.A. Googins, A. Malley and H. Poarea. 1976. Tussockosis: reactions to Douglas-fir tussock moth. Ann. Allergy 36: 302-307.

Ross, D.W. and S. Taylor. 1983. Effects of the current (1980-1984) Douglas-fir tussock moth outbreaks on forest resources and other values. B.C. Min. Forests, Internal Rpt. PM PB-9.

Shepherd, R.F. (Ed.). 1980. Operational field trials against the Douglas-fir tussock moth with chemical and biological insecticides. Can. For. Serv., Pac. For. Res. Cent. Inf. Rep. BC-X-201. 19 p.

Shepherd, R. F., I. S. Otvos and R. J. Chorney. 1984a. Pest management of Douglas-fir tussock moth: a sequential sample method to determine egg mass density. Can. Entomol. 116: 1041-1049.

Shepherd, R. F., I. S. Otvos, R. J. Chorney and J. C. Cunningham. 1984b. Pest management of Douglas- fir tussock moth: prevention of an outbreak through early treatment with a nuclear polyhedrosis virus by ground and aerial applications. Can. Entomol. 116: 1533-1542.

Shepherd, R. F. 1985. Pest management of Douglas-fir tussock moth: measuring larval density by sequential sampling. Can. Entomol. 117: 1111-1115.

Shepherd, R. F., I. S. Otvos and R. J. Chorney. 1985a. Sequential sampling for Douglas-fir egg masses in British Columbia. Can. For. Serv., Pac. For. Res. Cent., Joint Report. 15.

Shepherd, R. F., T.G. Gray, R. J. Chorney and G.E. Daterman. 1985b. Pest management of Douglas-fir tussock moth: monitoring endemic populations with pheromone traps to detect incipient outbreaks. Can. Entomol. 117: 839-848.

Some other aspects of the Doulgas-fir tussock moth problem are also discussed in the following U.S. Forest Service Publications. These publications may be obtained by contacting the USDA Forest Service, P.O. Box 3623, Portland, Oregon 97208.

Brooks, M. H., R. W. Stark and R. W. Campbell. 1978. The Douglas-fir tussock moth: a synthesis. U.S. For. Ser., Tech. Bull. 1585.

Gregg, T. and D. B. Twardus. 1981. Detection and evaluation procedures for potential Douglas-fir tussock moth outbreaks. U.S. For. Ser., Portland, Inf. Rep.

Mason, R. R. 1978. Detecting suboutbreak populations of the Douglas-fir tussock moth by sequential sampling of early larvae in the lower tree crown. U. S. For. Ser., Res. Paper PNW 238.

Wickman, B.E., R. R. Mason and C. G. Thompson. 1973. Major outbreaks of the Douglas-fir tussock moth in Oregon and California. U. S. For. Ser., Gen. Tech. Rpt. PNW 5.

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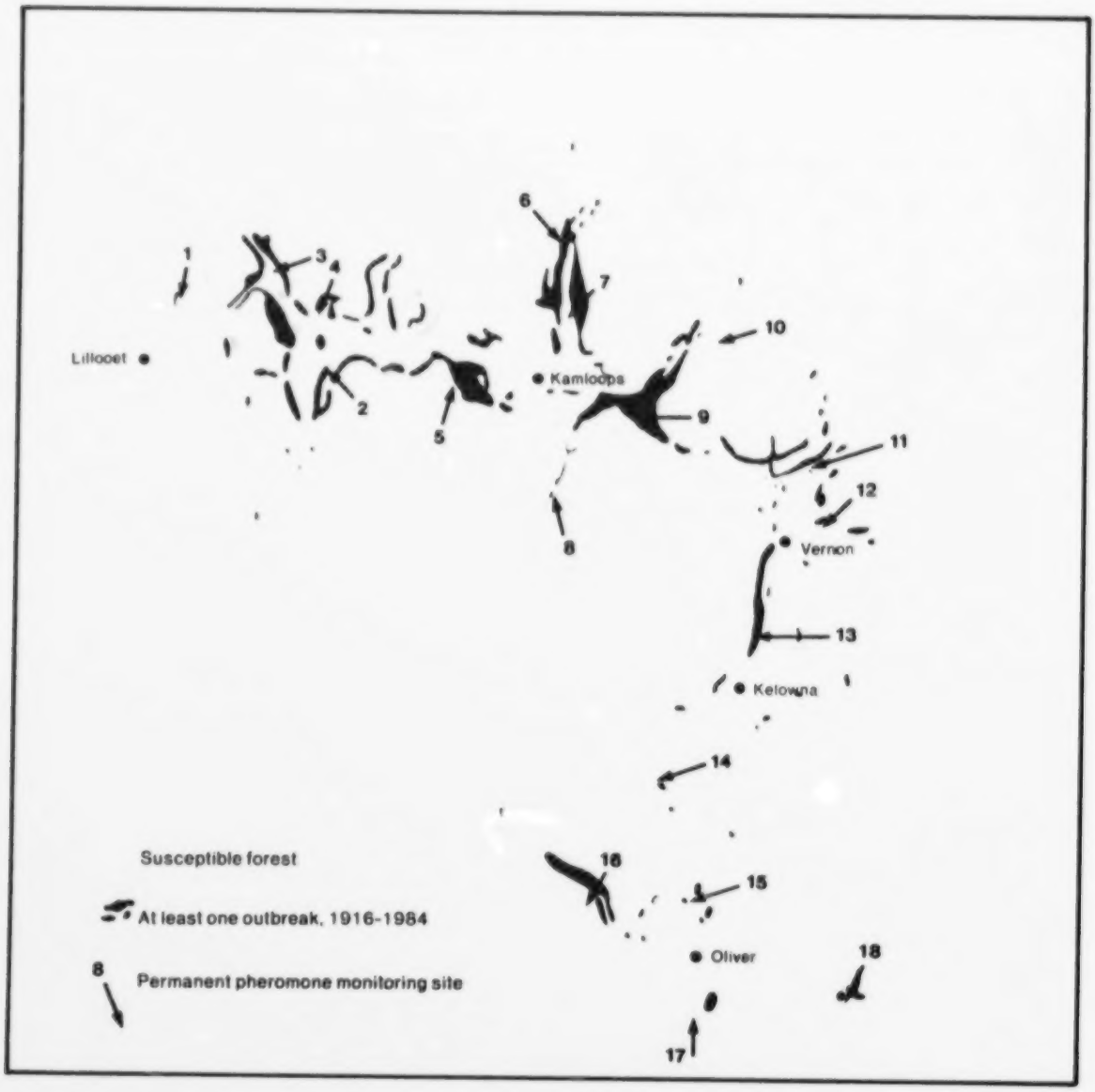
Lillooet
Kamloops
Vernon
Kelowna
Oliver
1
2
3
5
6
7
8
9
10
11
12
13
14
15
16
17
18
Susceptible forest
At least one outbreak, 1916-1984
Permanent pheromone monitoring site